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Agricultural Research Service

Potato Flakes

A New Form of Dehydrated

Mashed Potatoes

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I. Pilot-Plant Process Using

Double Drum Drier

POTATO FLAKES. A NEW FORM OF DEHYDRATED MASHED POTATOES
I. PILOT-PLANT PROCESS USING DOUBLE DRUM DRIER

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INTRODUCTION

To produce successfully a dehydrated mashed potato which can be rehydrated to the texture and appearance of the fresh product, at least two main requirements must be attained. First, the potato cells must be put in a form which will permit the rehydrating liquid to penetrate quickly, and second, the starch must be retained in the cells. Cell rupture both during manufacture and on reconstitution must be kept at a minimum so free starch liberated will not cause the reconstituted product to be pasty.

A number of products are being made which meet these requirements if rehydrating conditions are carefully controlled. Dried mashed potatoes are available in the form of granules, which are single cells or very small agglomerates of cells. These have been made by several methods described and catalogued in a recent comprehensive review by Olson and Harrington (1).

Mashed potatoes have also been dehydrated in particles much larger than granules. Among these are shreds, and hollow cylinders of about 1/8 inch in diameter having thin, porous walls (2,3,4).

The purpose of this paper is to describe the development of a simple process for making dehydrated mashed potatoes in a new form having unusual rehydration properties.

Recent work at the Eastern Utilization Research Branch has shown that a product of excellent color and flavor and of good texture can be made on a double drum drier if the factors governing cell rupture, film thickness and drying rates are properly controlled. We have termed the product "potato flakes."

PROCESS

Raw Material

To produce flakes on a double-drum drier, potatoes are first graded, peeled, trimmed, and sliced. Slices are washed to remove free starch, cooked in steam, and mashed. Mash is sulfited, diluted with water when desirable, applied to the drums in a manner assuring good adherence, and dried. Factors influencing cell damage and flake properties such as density, fragility, and dryness are closely controlled during drying.

For the production of good potato flakes, potatoes are required which will make a mealy, non-sticky mash before drying. In general they should be high starch varieties of low sugar content. Good results have been obtained with Russet Burbanks grown in Idaho, containing from 12 to 18 percent starch and up to 0.6 percent sugar. A product

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of excellent color and texture was made from potatoes as late as June. However, the flavor of this was inferior to the product made from potatoes not subjected to prolonged storage. The off-flavor was characterized as "sack flavor."

Since solids content is known to have a bearing on texture, sodium chloride brine solutions, having specific gravities of 1.090, 1.085 and 1.075, were used in separating the potatoes into fractions of different solids content. It was found that all potatoes of solids content above about 20% yielded a product of good texture. In general, the higher the specific gravity of the potato, the better the texture of the reconstituted product.

Peeling

Since the product of the drum drier is not usually comminuted and screened, practically all of the peel and eyes must be removed before drying. Conventional methods of washing, destoning, peeling and slicing should be satisfactory in the flake process. In choosing a peeling method it should be recognized that the highest starch fraction lies nearest the skin (5). Excessive peeling losses thus not only reduce yields but impair texture of product.

Slicing and Cooking

Potatoes were cut to 3/4" thick slices, using the Urschel Laboratories, Inc., Model B Dicer, Strip Cutter and Slicer.[1] The slices were washed thoroughly to remove free starch from the cut surfaces. For cooking, they were placed on a 4-mesh screen tray usually only one slice deep; the tray placed horizontally inside the cooker and atmospheric steam was introduced so as not to impinge directly on the slices. Tests were made to determine the effect of cooking time. Temperature measurements made with a thermocouple inserted into the center of a potato slice showed that a time of 10 minutes was required to bring the center to 212° F. Potatoes cooked for 12, 20 and 35 minutes were compared for texture after reconstitution of flakes. Those cooked 12 minutes (2 minutes after reaching 212°F.) had much better texture when mashed than the other two. Potato slices cooked only 12 minutes had the appearance of being undercooked, however, and were difficult to mash in a planetary type mixer. Slices cooked 15 minutes (5 minutes at 212°F.) were mashed without difficulty in the mixer, and the product showed no apparent cell damage by overcooking. This is a shorter cooking time than is generally used for granules. Since the consistency of the mash depends somewhat on the cooking time, it is desirable to use comparatively thin layers of slices in the cooker to avoid overcooking in some portions and undercooking in others.

Mashing and Incorporation of Additives

For convenience in incorporating additives a batch planetary type mixer was used for mashing. There does not appear to be any reason why mashing rolls could not be used as in the granule process.

A solution of sulfite salts is used to lighten the color of the product and increase storage stability. Three parts of Na_2SO_3 to one part of $NaHSO_3$ used as a solution containing 10% by weight of SO_2 has proved satisfactory. When incorporated in the mash at the rate of 400 parts per million of SO_2, about 200 ppm are retained in the dried product. This imparts no detectable taste.

The use of $CaCl_2$ as a firming agent was investigated. When added to the mash to the extent of .05% as used by Barker and Burton (6) there was some decrease in cell rupture as

[1] MENTION OF BRAND OR TRADE NAME IN THIS PAPER DOES NOT IMPLY THAT THE ARTICLE IS RECOMMENDED OR ENDORSED BY THE U. S. D. A. OVER SIMILAR ARTICLES NOT MENTIONED.

measured by analysis for free starch,[2] but no significant improvement in texture of the reconstituted product. Since an off-flavor resulted from its use, $CaCl_2$ treatment was abandoned. The incorporation of an emulsifying agent such as glyceryl monolaurate has been reported to be advantageous in the production of potato granules (7). The addition of 0.25% on a dry solids basis to the mash produced a marked increase in the mealiness of the mash before drying. However, improvement was not carried through to the final product when reconstituted. Further investigation of the reagent may be justified.

Drying

Feeding mash to the drums: If a mass of mashed potato is placed in the "V" between the rolls of a 6-inch diameter double drum drier which in this case turn downward toward each other, there will be practically no pickup on the rolls. Even while still hot, a mashed potato is too stiff to flow far enough into the pinch of the rolls to be picked up and carried through the aperture. To obtain a uniform sheet on both drums, mash in the "V" must be kept in motion with an action which wipes it on clean drums and presses it into the aperture. This results in a thin film adhering to the hot surfaces before the drums converge at the pinch, and the rough surfaces thus created aid the acceptance at the pinch. This motion was accomplished in the pilot plant by manipulation of the mash with a paddle, but it can be simulated mechanically.

It is expected that when a drier of larger diameter is used, the increased area of pinch resulting from the lesser angle of approach will aid the feeding of the mash.

Roll clearance. The clearance between the rolls is one of the most critical factors determining the quality of mash the flakes will yield. In general flakes thinner than 0.004 inch contain an excessive number of ruptured cells. It is not feasible to dry uniformly a film of much above .009 inch on a double drum drier. Greater thickness tends to favor good product texture. Figure 1 shows photomicrographs of rehydrated potato flakes of different thickness and shows variation in cell rupture with thickness. The increased amount of agglomeration can be seen particularly at 0.007" (D) but this is in no way objectionable. In practice, the best film thickness lies between 0.005 inch and 0.009 inch.

The above dimensions are for flake thickness, as measured with a micrometer. The final thickness of the flake is dependent on two other factors as well as the spacing between the rolls, i.e., the amount of "pulling apart" which occurs when the two films separate after leaving the pinch and the degree of shrinkage on loss of water. When using the drier described for these experiments we obtained two dried flakes each having a thickness about 0.6 times the clearance between the rolls. For example, with the rolls spaced 0.008 inch apart we would obtain two dried films each about 0.005 inch thick. The roll clearance corresponding to the optimum flake thickness would then be between .007 and .014 inch which is well within the operating range of larger commercial driers.

The potatoes used for these measurements were Idaho Russet Burbanks having a cell size distribution as shown in Figure 2. The cells are ellipsoidal and the size shown is their long dimension. Referring to Figure 2, it is apparent that about 45% of the cells are larger than 0.008 inch and would be expected to rupture in passing through an 0.008 inch clearance. Since they do not, it is concluded that they pass through sideways or can withstand considerable distortion.

[2] Olson, R. L., Harrington, W. O., Neel, G. H., Cole, M. W. and Mullins, W. R., Recent Advances in Potato Granule Technology. Food Technology, Vol. 7, No. 4, pp. 177-181, 1953.

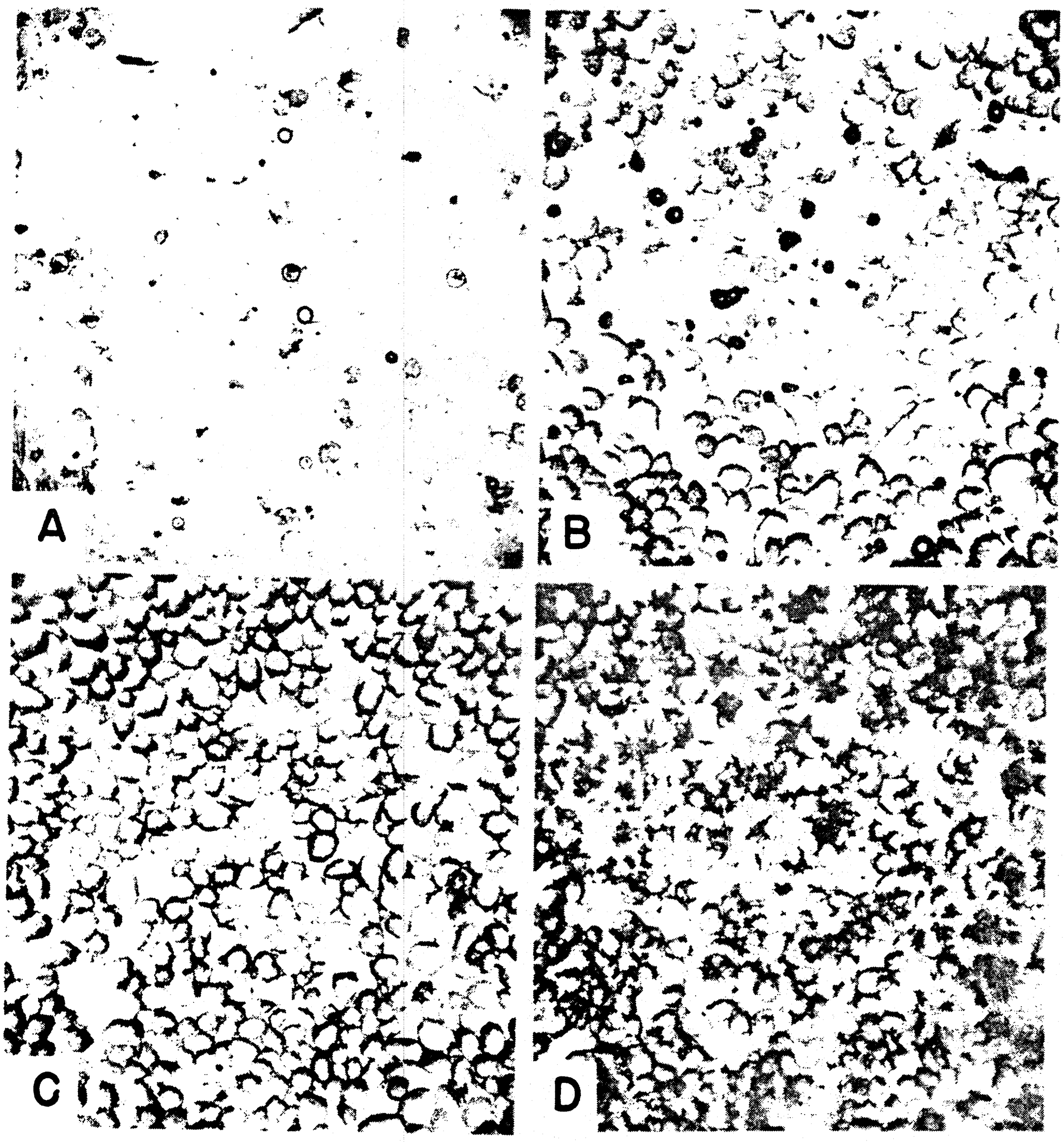

FIGURE I. REHYDRATED POTATO FLAKES. MAGNIFICATION 20X

THICKNESS BEFORE REHYDRATION

A: 0.001"

B: 0.003"

C: 0.004"

D: 0.007"

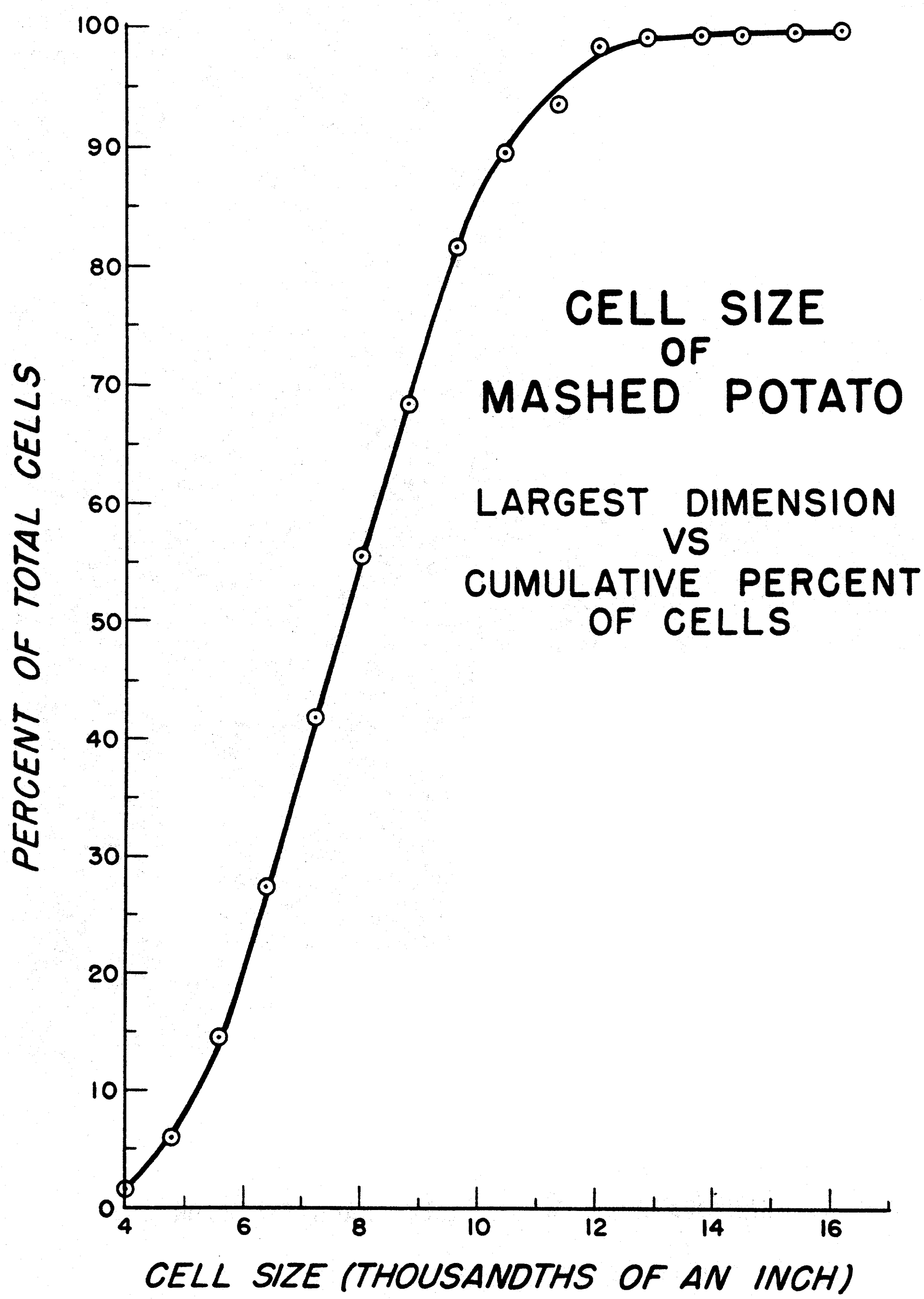
CELL SIZE
OF
MASHED POTATO
LARGEST DIMENSION
VS
CUMULATIVE PERCENT
OF CELLS
PERCENT OF TOTAL CELLS
0
10
20
30
40
50
60
70
80
90
100
4
6
8
10
12
14
16
CELL SIZE (THOUSANDTHS OF AN INCH)

FIGURE 2.

Drum temperature and speed: To enhance storage stability it is desirable to produce, without damage to texture or flavor, flakes of as low moisture content as possible. A standard for granules has been set at 7% or lower (8). The industry is tending toward moisture of 4% or lower. This is currently sought in the granule process by two-or three-stage drying. Flakes can be dried at 4% or lower moisture in one stage.

In most drum drying procedures the steam pressure is set as high as possible. Tests were made to find the limits of steam pressure, residence time and final moisture content beyond which an objectionable scorched flavor was imparted to the product. Using Idaho potatoes containing 22% solids and about 0.3% sugar (1.4% MFB) the "scorch area" was determined and is shown in Figure 3 in which curves of flake moisture vs. roll temperature at different roll speeds are shown. It is apparent that a moisture content of 4% could be made without scorching either at a drum speed of 3 rpm and a drum temperature of 318° F. or at a speed of 2.4 rpm and a temperature of 308° F.

The data plotted apply only to the potatoes described above, undiluted before drying.

Dilution of mash: It has been observed that dilution within certain limits results in lower moisture content of the finished product at the same drying conditions. This is due to better adherence to the drums with higher efficiency of heat transfer.

Potatoes of high solids content yield a mash difficult to apply undiluted to the drying drums so as to produce a dense dried sheet of product. When diluted within limits, however, mash made from high solids potatoes is easier to apply and produces a drier, denser and stronger sheet than the same mash undiluted. Flakes from diluted mash, when reconstituted yield a product of improved texture and greater tolerance for higher temperature reconstitution. This is probably due in a large part to their lower moisture. The benefits of dilution reach a maximum when high solids potatoes are diluted to approximately 20% to 22% solids. Dilution beyond this range is conducive to cell rupture and a pasty product.

The effect of dilution on bulk density and strength of the flake is illustrated in Figure 4. These data were obtained by drying mash prepared from high solids potatoes, both undiluted and diluted to different solids contents, breaking the dried sheets, and screening them into different size fractions. Change in bulk density with dilution for the fraction passing 10-mesh and retained on 20-mesh is shown on Figure 4, curve A, indicating a peak density between 20 and 21% solids. Further dilution results in decreasing density. Since flake density is also affected by drum speed, all tests were made at the same speed. Recovery of large pieces (passing 1-mesh and retained on 2-mesh) after breakage of the sheets increases as dilution of the mash increases, and a peak recovery is reached at about the same dilution as the peak density. This is shown on Figure 4, curve B.

PROPERTIES OF RECONSTITUTED PRODUCT

Potato flakes rehydrate rapidly on addition of water at temperatures ranging from 50°F. to boiling. Usually for reconstitution of flakes, 4 to 4-1/2 parts of liquid at about 160°F. are used. This temperature is conveniently achieved by mixing 2 parts of boiling water with 1 part of cold milk. The liquid is poured over the flakes until the entire mass is moistened. Butter and salt are added to taste and the product lightly whipped if a creamy consistency is desired. If the flake is made from a high solids mash diluted to about 20% solids before drying, boiling liquid can be used for reconstitution. Commercial products recommend reconstitution with liquid at about 160°F. It is an obvious advantage to be able to reconstitute over a wide range of temperature, including boiling, as such a product would be more foolproof. In

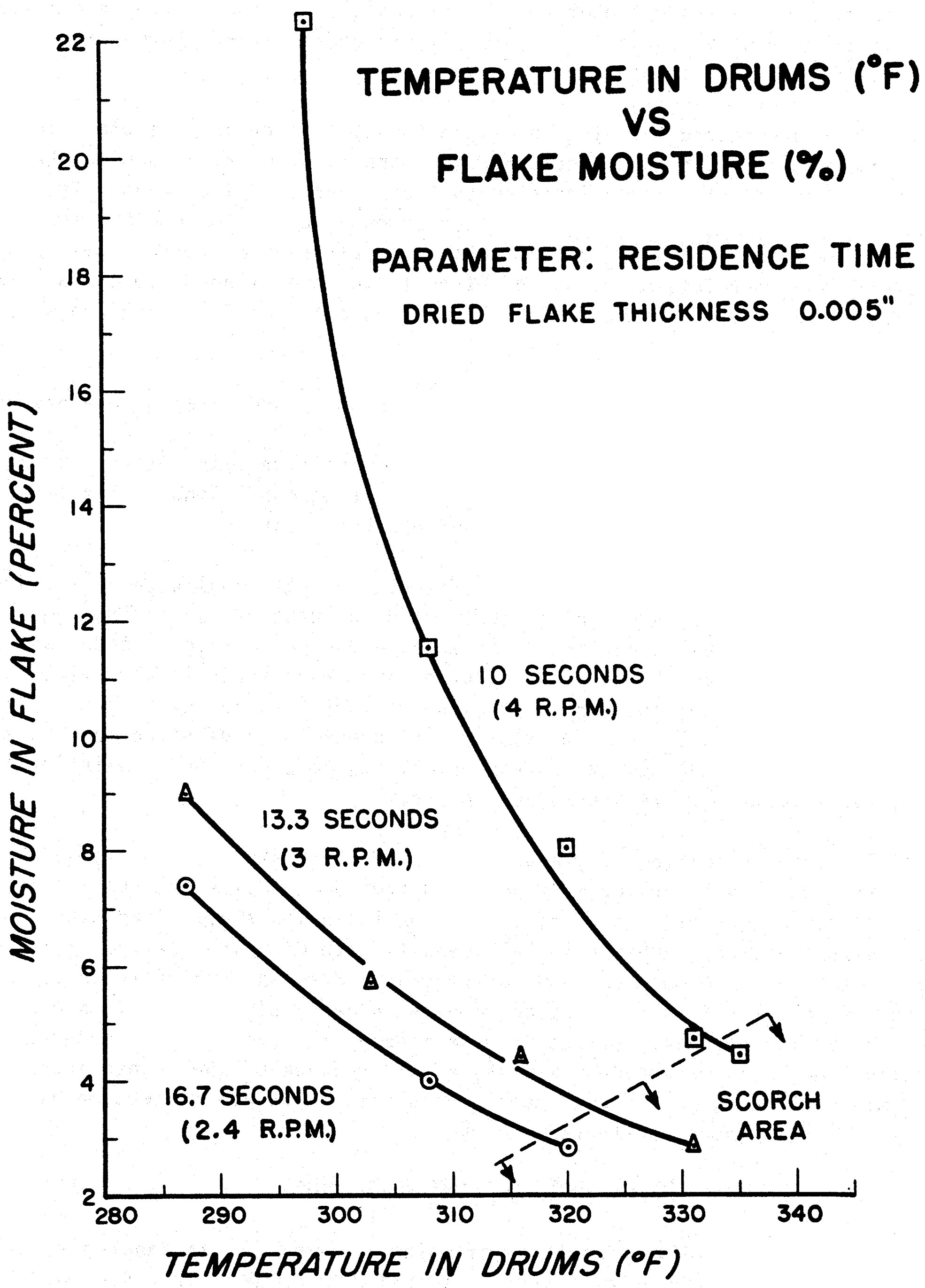
TEMPERATURE IN DRUMS (°F)
VS
FLAKE MOISTURE (%)
PARAMETER: RESIDENCE TIME
DRIED FLAKE THICKNESS 0.005"
10 SECONDS
(4 R.P.M.)
13.3 SECONDS
(3 R.P.M.)
16.7 SECONDS
(2.4 R.P.M.)
SCORCH
AREA
MOISTURE IN FLAKE (PERCENT)
TEMPERATURE IN DRUMS (°F)
22
20
18
16
14
12
10
8
6
4
2
280
290
300
310
320
330
340

FIGURE 3.